

CYCLE LIFE VS DEPTH OF DISCHARGE  
UPDATE ON MODELING STUDIES

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The Aerospace Corporation

Presented At

1993 NASA Aerospace Battery Workshop  
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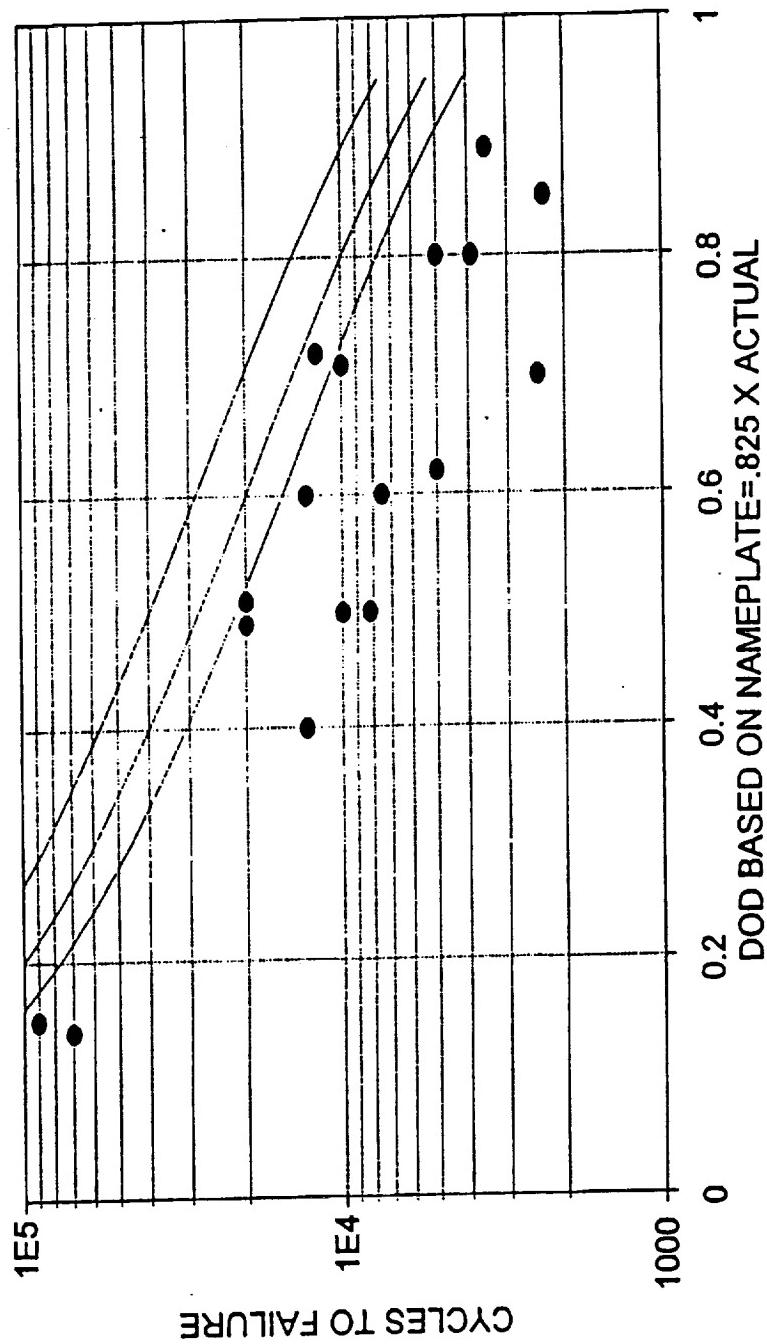
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## PROCESS INVOLVED

- o COLLECTED DATA FROM VARIOUS SOURCES
  - MARTIN MARJETTA
  - AIR FORCE/CRANE
  - NASA LeRC
    - JOHN SMITHRICK
    - SPACE STATION
  - IECEC PAPERS
- o PLOTTED DATA AGAINST BACKDROP OF SIMPLE WEAROUT MODEL
- o MADE SOME GENERAL STATEMENTS BASED ON AVAILABLE DATA
- o CONSIDERED OTHER DEGRADATION MECHANISMS
- o CONCLUDING REMARKS

The reader is referred to the 1990 NASA Battery Workshop Paper by L. Thaller for background formulas and information on this topic.

CYCLE LIFE VS DEPTH OF DISCHARGE  
DATA AS OF THREE YEARS AGO

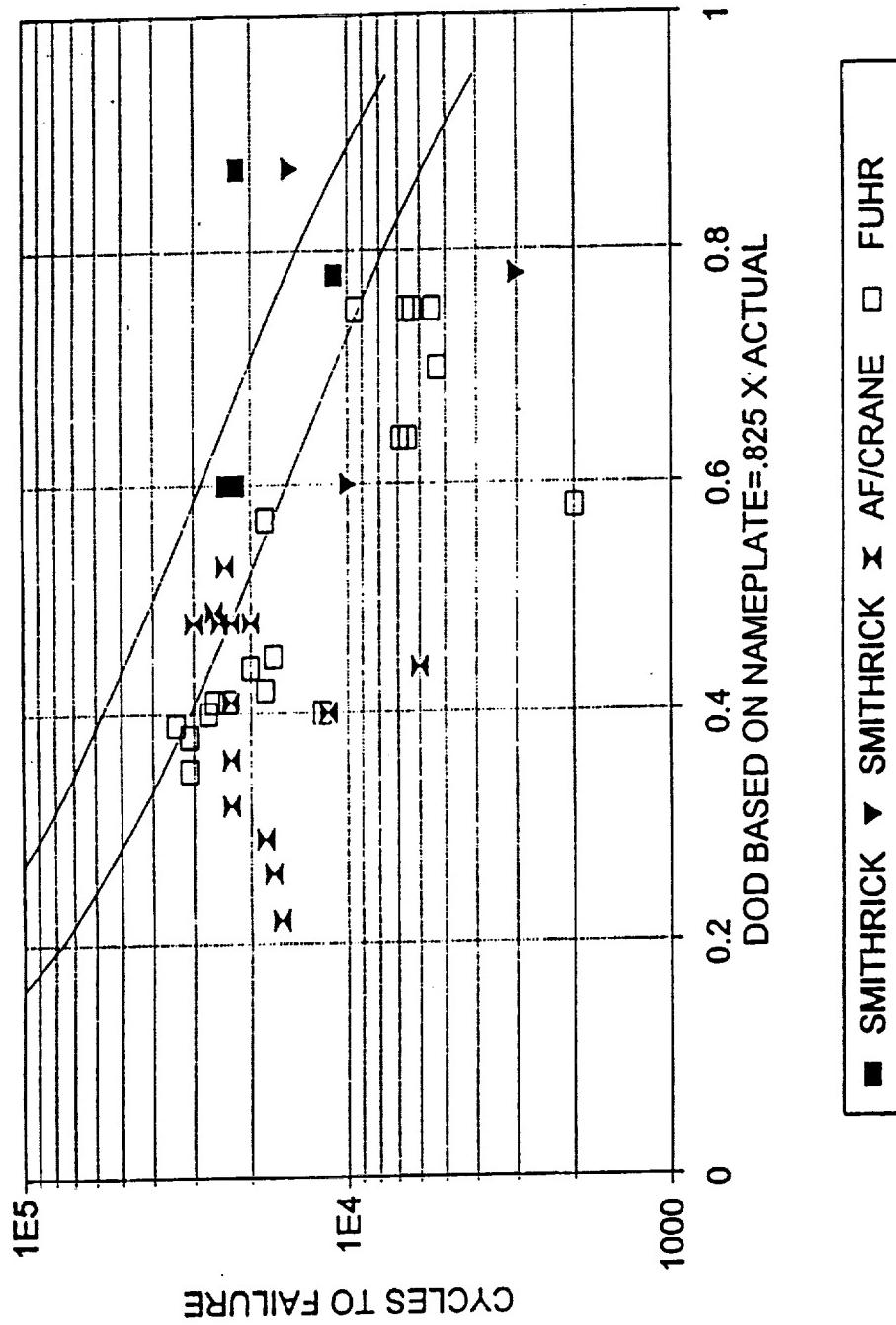


● ALL AVAILABLE DATA

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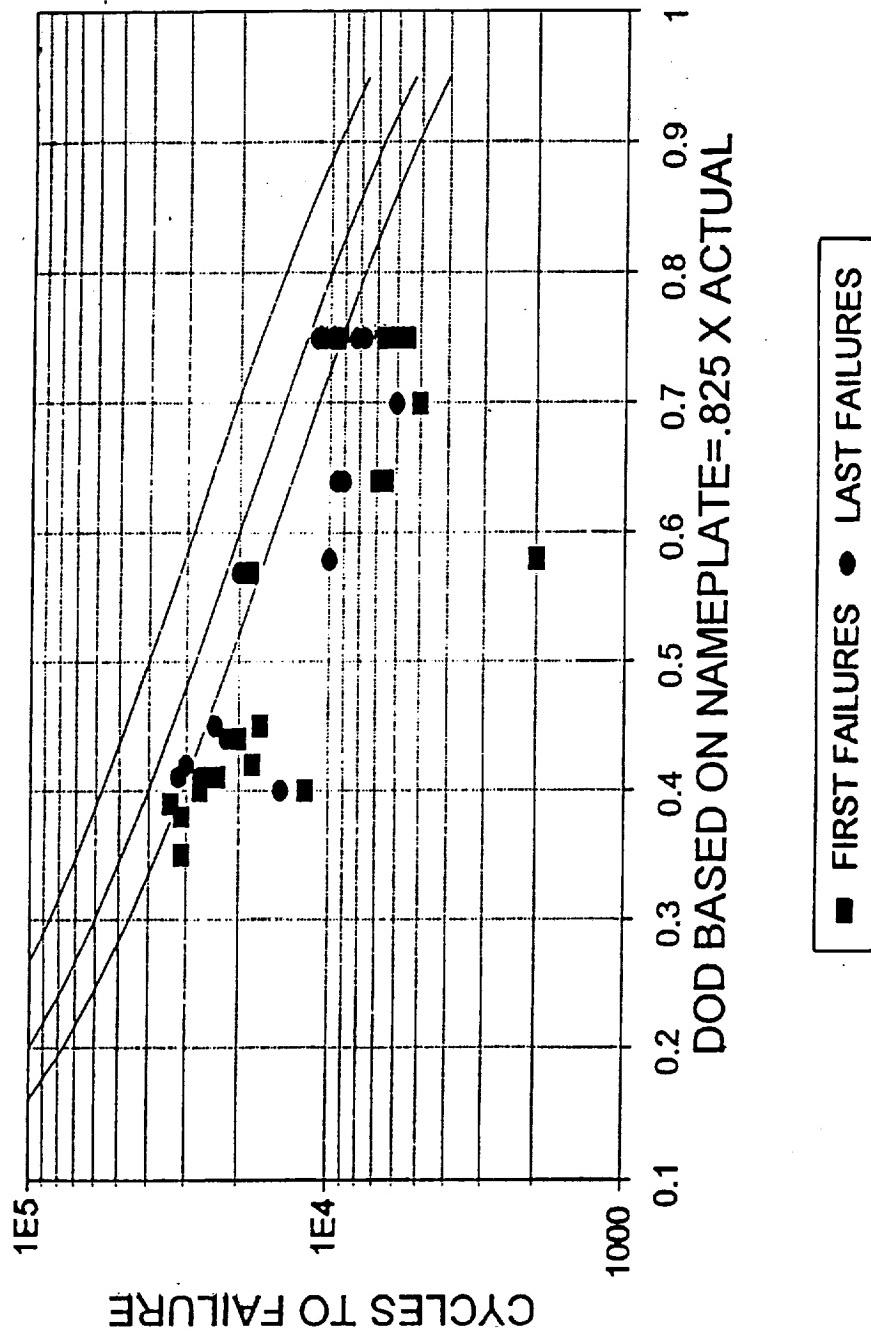
CYCLE LIFE VS DEPTH OF DISCHARGE  
AF/CRANE-FUHR-SMITHRICK



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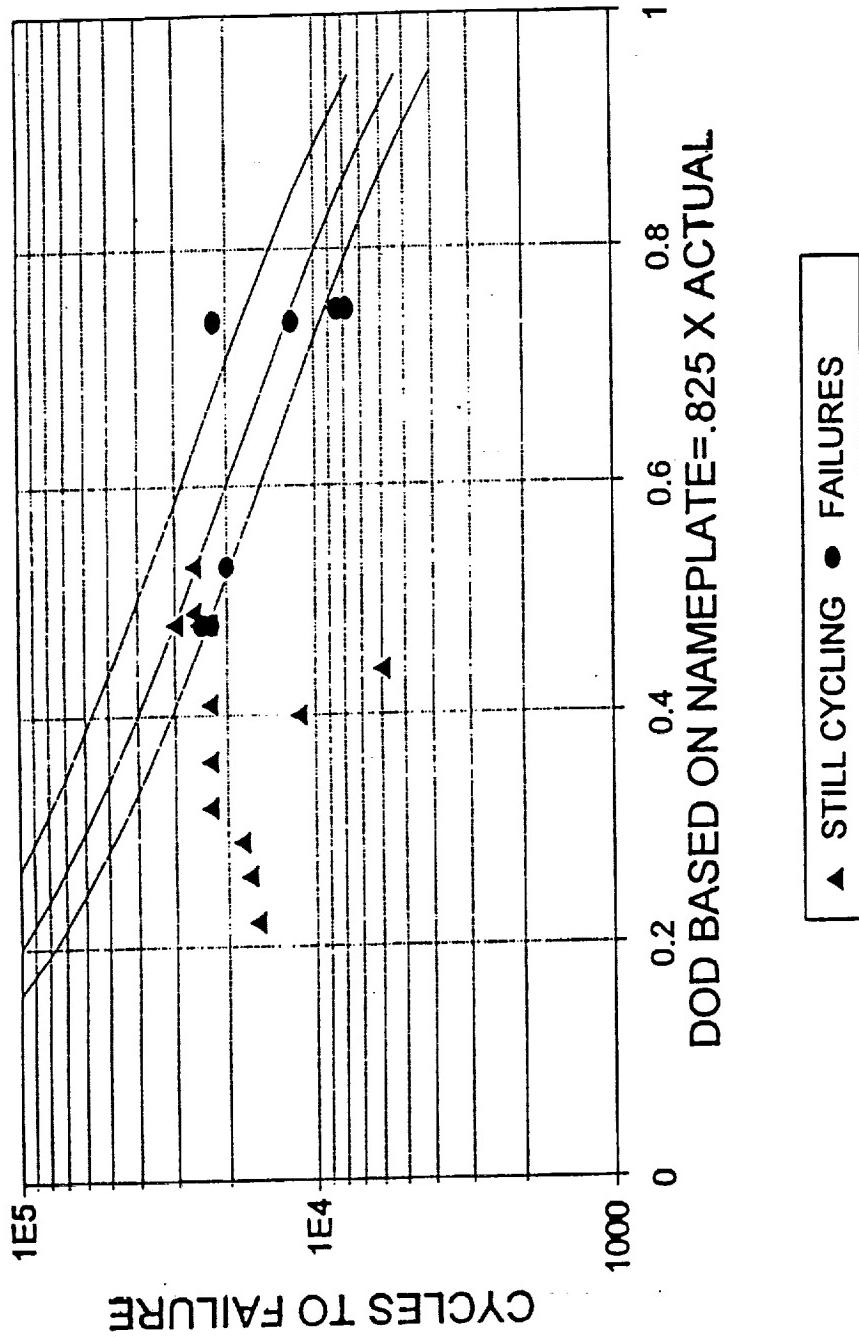
# CYCLE LIFE VS DEPTH OF DISCHARGE KEN FUHR'S DATA



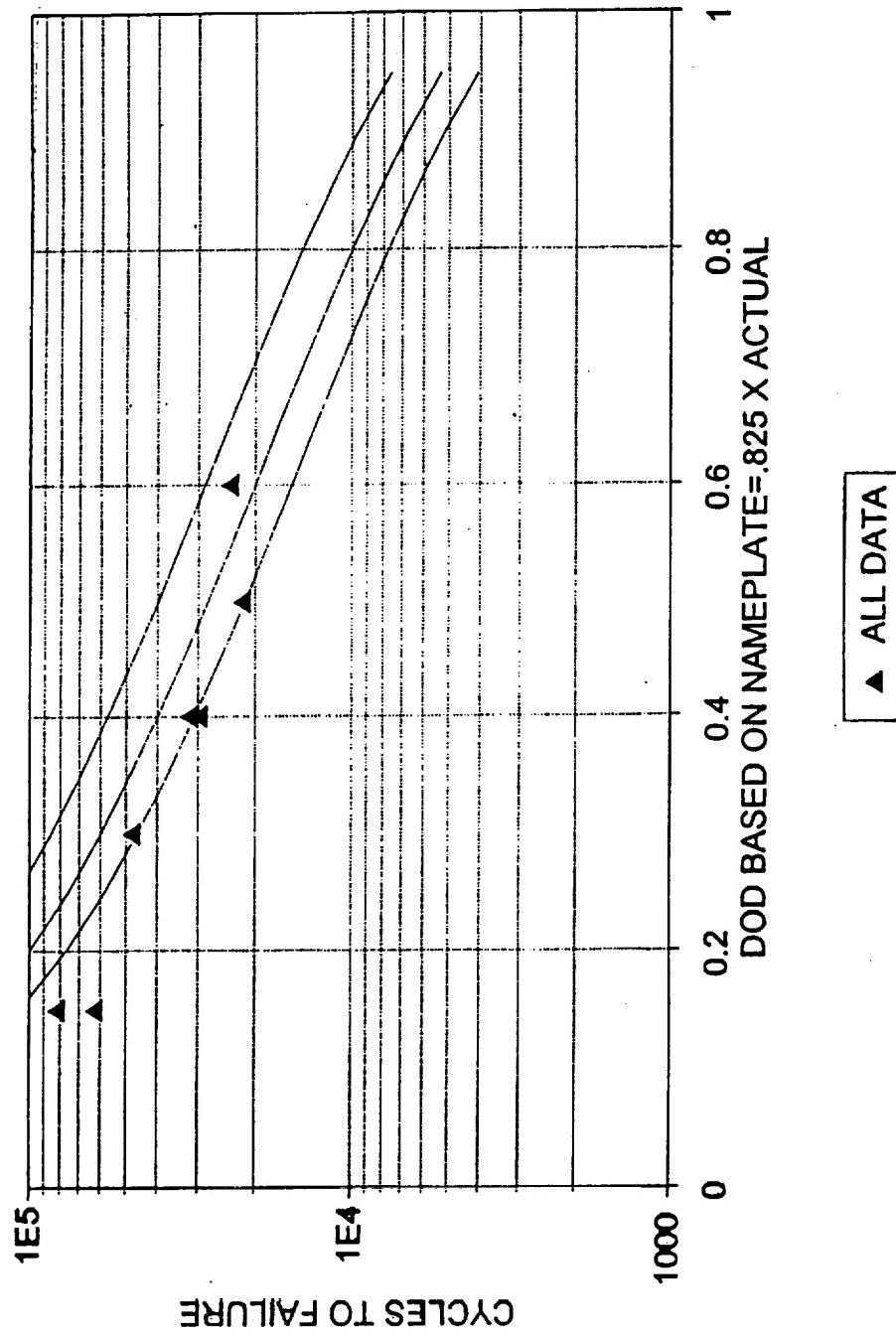
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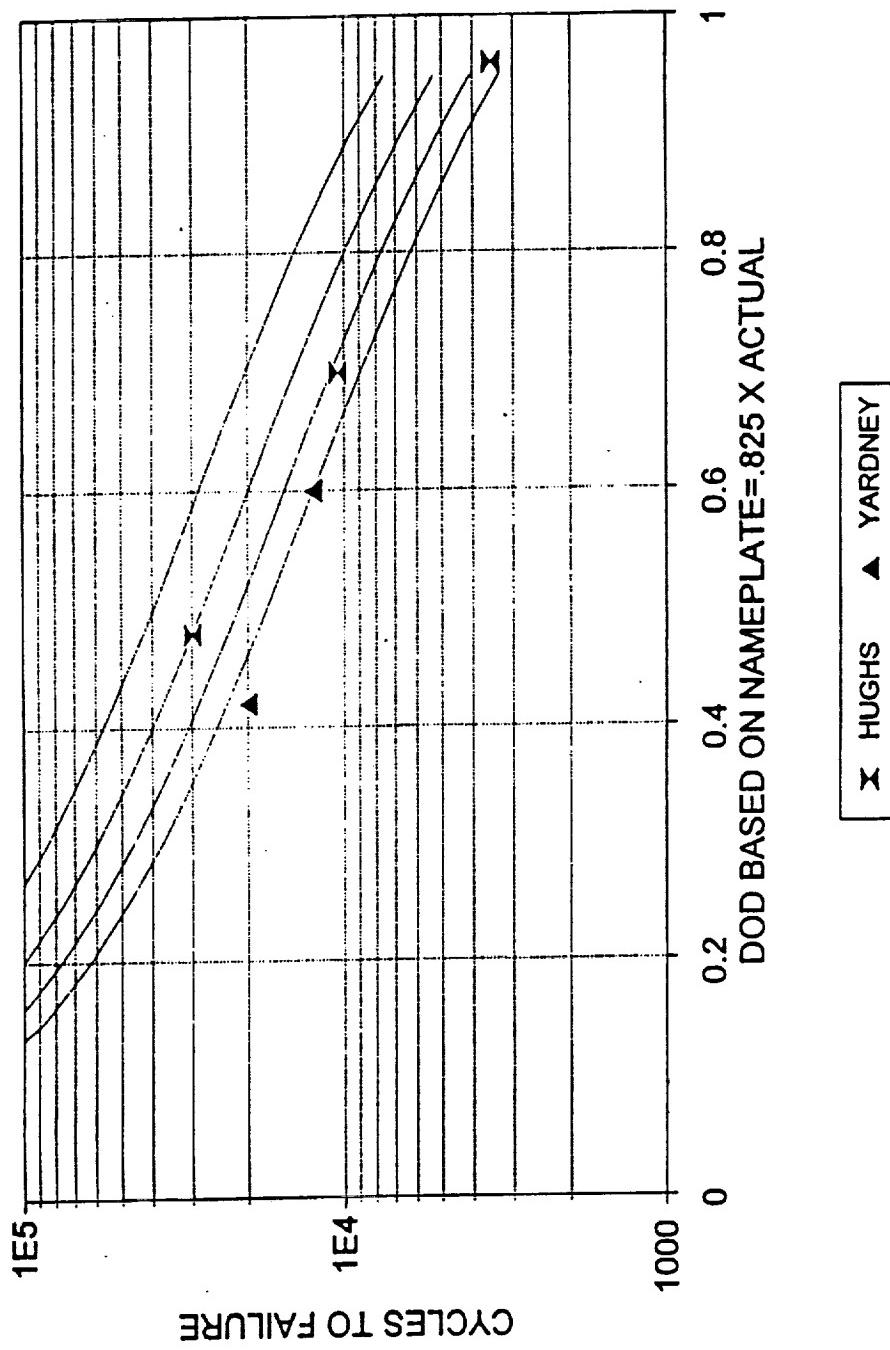
## CYCLE LIFE VS DEPTH OF DISCHARGE AIR FORCE/CRANE DATA



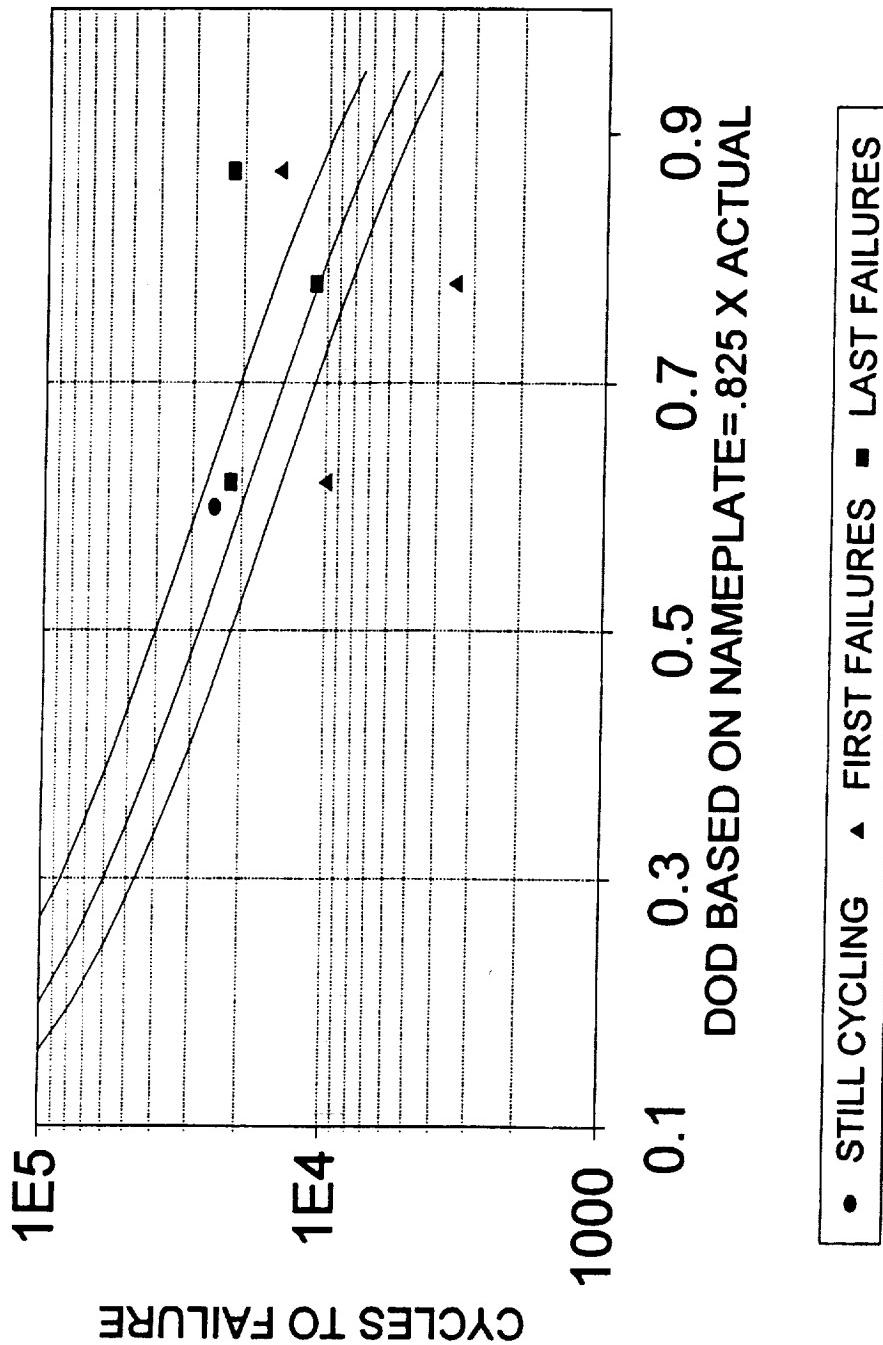
CYCLE LIFE VS DEPTH OF DISCHARGE  
EAGLE-PICHER DATA



CYCLE LIFE VS DEPTH OF DISCHARGE  
STEVE SCHIFFER'S DATA



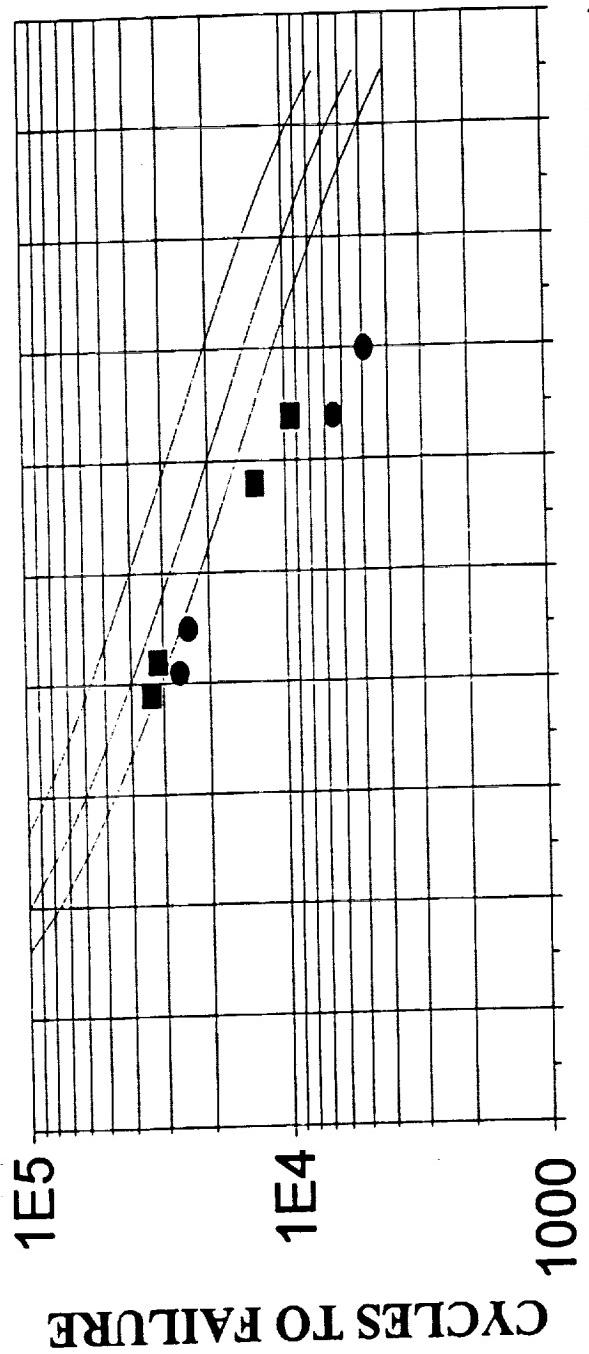
# CYCLE LIFE VS DEPTH OF DISCHARGE JOHN SMITHRICK'S DATA



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## CYCLE LIFE VS DEPTH OF DISCHARGE TEMPERATURE EFFECTS



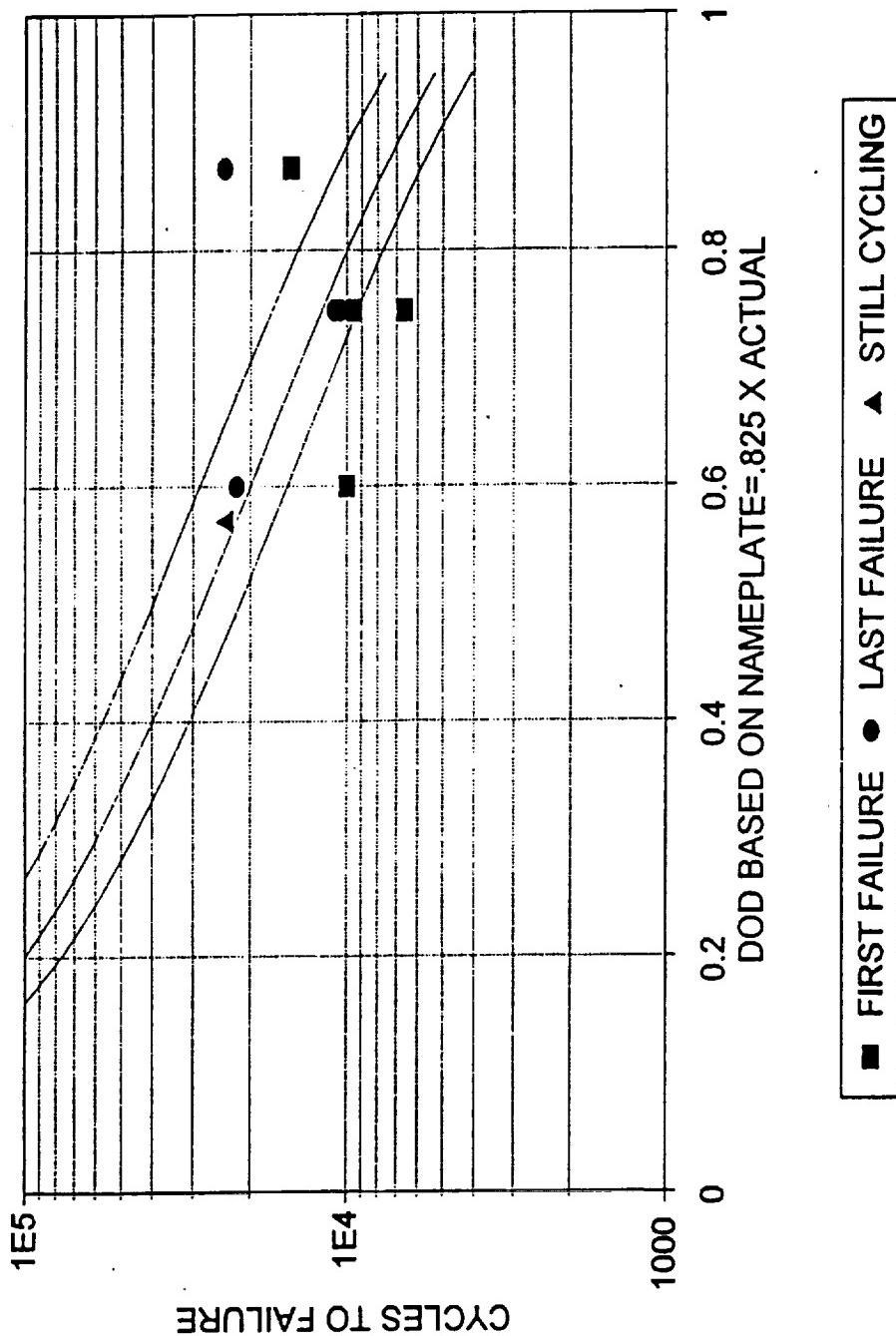
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1  
DOD BASED ON NAMEPLATE=.825 X ACTUAL

- ■ - 10 Deg.C
- ● - 20 Deg.C



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CYCLE LIFE VS DEPTH OF DISCHARGE  
E-P, YARDNEY, AND HUGHES 26% DATA

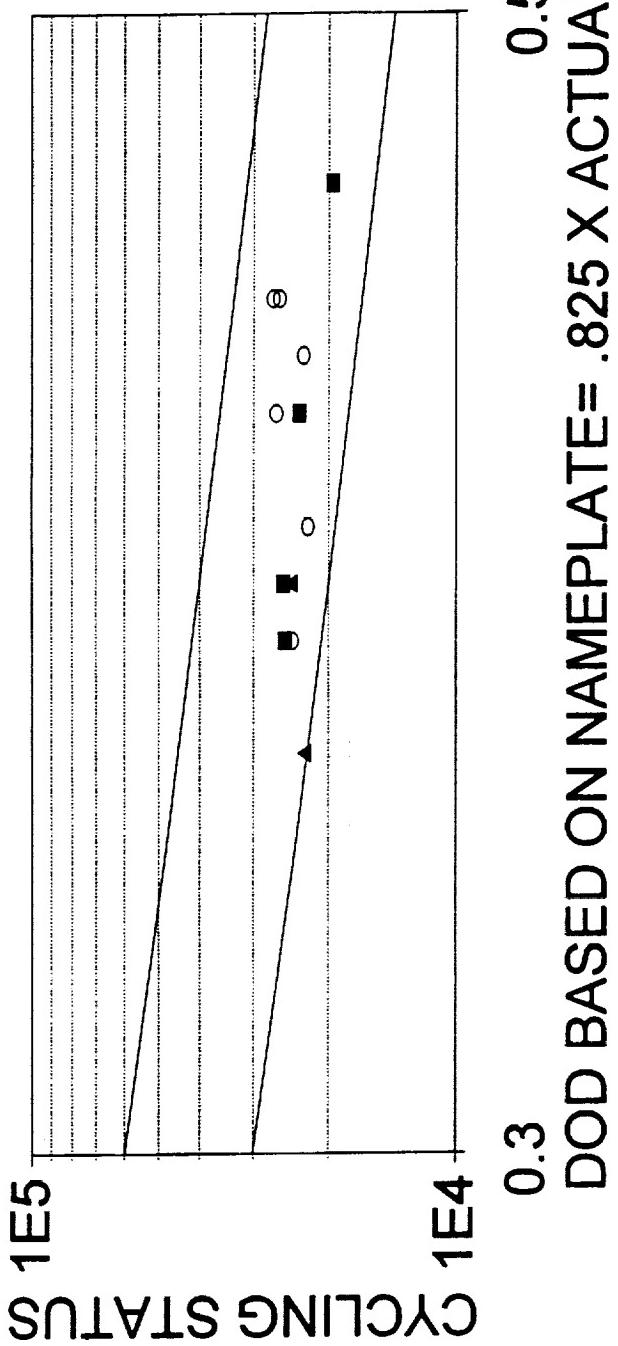


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# YARDNEY "SPACE STATION" CELLS

## NASA LeRC CYCLING TESTS



- FAILED 31% → 31% KOH-CYCLING
- 26% KOH-CYCLING



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## GENERAL STATEMENTS

- o CYCLING DATA STRONGLY SUGGEST THAT:
  - DROPPING TEMPERATURE INCREASES CYCLE LIFE
  - USING 26% KOH VS. 31% KOH INCREASES CYCLE LIFE
  - CYCLE LIVES AMONG "LIKE" CELLS CAN VARY WIDELY (+/- 50%)
  - CELL FAILURES OCCUR FOLLOWING 25 TO 30% LOSS OF CAPACITY
  - CAPACITY CHECKS PROBABLY DO NOT EFFECT CYCLE LIFE

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## GENERAL OBSERVATIONS

- o CYCLE LIVES GENERALLY IMPROVING - ESPECIALLY AT DEEP DODs
- o NAMEPLATE CAPACITIES SHOULD BE STANDARDIZED
- o SOME CELL DESIGNS MAY NO LONGER BE AVAILABLE

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## GENERAL STATEMENTS

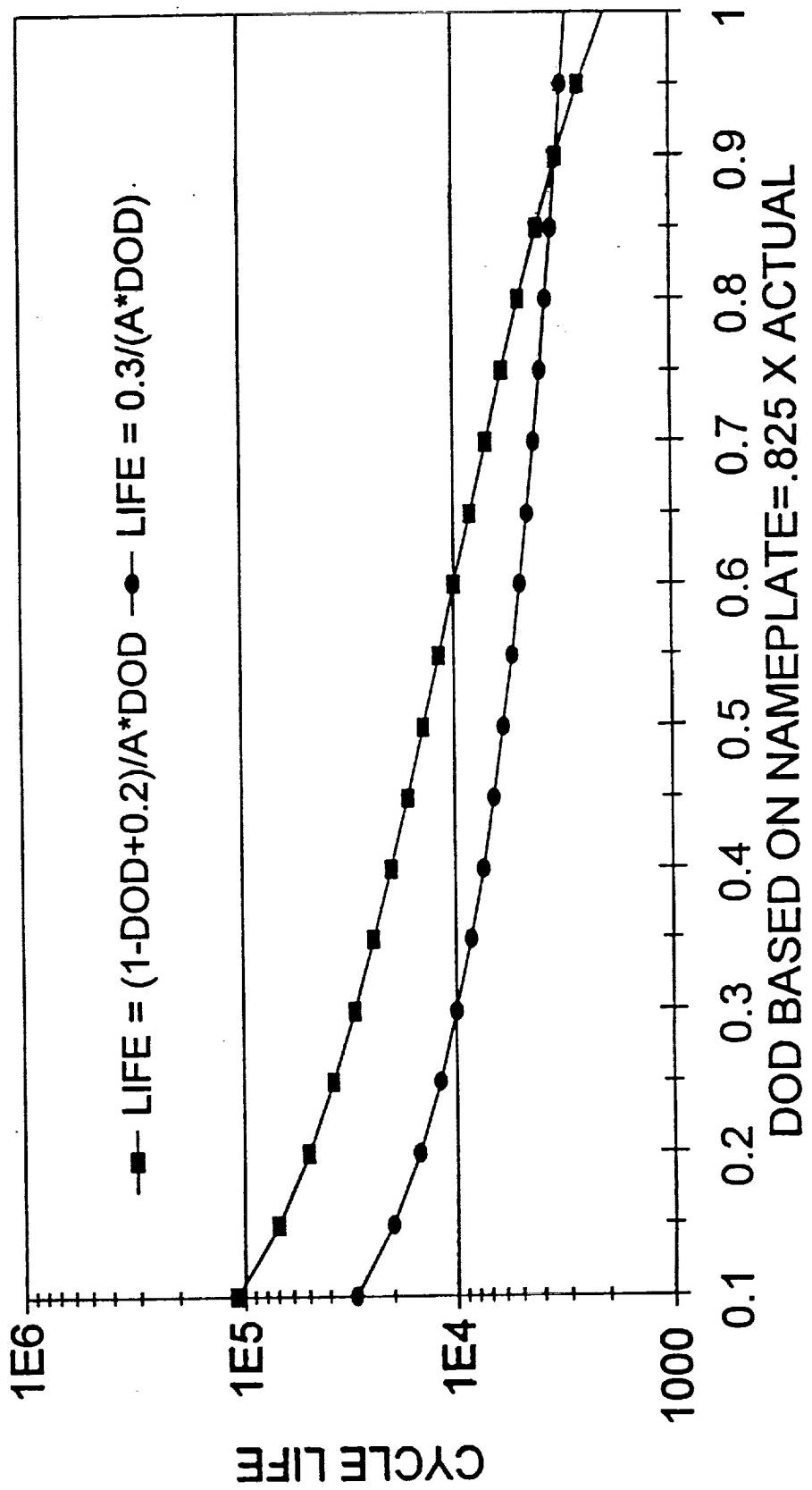
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# CYCLE LIFE VS DEPTH OF DISCHARGE TWO DIFFERENT MODELS



## OTHER DEGRADATION MODES

- o EXCESS ELECTROLYTE
- o CONTAMINANTS (NATURAL) IN ASBESTOS
- o HIGH SURFACE LOADING OF ACTIVE MATERIAL
- o COLD FINGERING OF WATER VAPOR
- o INSUFFICIENT PROVISION FOR STACK EXPANSION



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## SUGGESTED DOs AND DON'Ts

- o DO:
  - USE CELL DESIGNS THAT OVERCOME KNOWN CELL PROBLEMS
  - CONSIDER ELECTROLYTE, THERMAL, AND GAS MANAGEMENT ISSUES
  
- o DON'T:
  - USE ASBESTOS THAT HAS NOT BEEN PROPERLY REMANUFACTURED
  - USE DESIGNS THAT WERE INTENDED FOR GEO IN LEO



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## CONCLUDING REMARKS

- o CELL DESIGN FACTORS VERY IMPORTANT TO CYCLE LIFE
- o CYCLE LIVES AT DEEP DODs GENERALLY IMPROVING
- o 40,000 TO 50,000 CYCLES AT 40% DOD NOT AN UNREASONABLE GOAL
- o CYCLE LIFE TESTING MUST CONSIDER CYCLING TO 50 TO 70% DOD
- o MECHANICAL DESIGN CHANGES CANCEL OUT ESTABLISHED DATA BASES
- o SIMPLE EQUATIONS DON'T ACCURATELY FIT OBSERVED FAILURES



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